CLINICAL AND EPIDEMIOLOGICAL INVESTIGATION TO EXCLUDE FOOT AND MOUTH DISEASE IN CATTLE

Introduction

An outbreak of foot and mouth disease (FMD) has the potential to have a significant economic effect in New Zealand through loss of markets for agricultural products. Financial losses would continue, owing to lost production capacity, even after trading partners were satisfied that the disease had been eradicated. Therefore, it is important that New Zealand has a robust biosecurity system for preventing the entry of FMD, and an efficient investigation and response system for early detection and mitigation of spread should an incursion ever occur.

The Investigation and Diagnostic Centre (IDC) Wallaceville is charged with investigating and excluding FMD and other foreign animal diseases from our livestock. The IDC regularly receives calls from animal health professionals and farmers regarding suspicious signs in livestock. Most calls relate to suspected FMD in cattle rather than other production animals. Very few notifications involve more than one affected animal.

Some endemic diseases in cattle can be clinically confused with FMD. These include bovine viral diarrhoea (BVD), mucosal disease (MD), papular stomatitis (PS), actinobacillosis caused by *Actinobacillus lignieresii* (woody tongue or WT), malignant catarrhal fever (MCF), phototoxic dermatitis (PD), footrot and traumatic injury (Holliman, 2005) (Table 1). However, some notifications received by IDC investigators do not fit into any of the classical FMD differentials listed in Table 2. In most of these cases the exact cause of the condition remains undetermined.

This paper describes the investigation methods for exclusion of FMD in cattle and outlines the clinical presentation and laboratory results from several idiopathic vesicular and erosive conditions where FMD was excluded. In addition, a pictorial library of lesions from clinical FMD is provided (Figure 5) and some of the more common endemic differentials of FMD are shown in Figures 6–11.

Methods

Incursion investigators are alerted to suspect FMD cases via the MAF exotic disease and pest hotline. Each notification is risk-assessed according to species, morbidity/mortality, location of lesions (feet, oral, and teat), lesion description and whether fever is present. In addition, other potential risk factors for introduction of FMD are assessed. These include a temporal association between disease in animals on the affected property, and movements of people and goods from overseas or introductions of livestock from other parts of New Zealand. Key people from both MAF and industry are placed on alert until FMD is excluded and the investigation is stood down.

Almost all notifications result in a field visit by a veterinarian, even if the risk is assessed as low. The investigation incorporates visits by veterinarians with specialised biosecurity training (Initial Investigating Veterinarians) and subsequently by an Incursion Investigator where FMD cannot be excluded by the Initial Investigating Veterinarian. Veterinary investigators carry out a full clinical examination on affected animals and, where indicated, on a sample of animals from the same herd not showing clinical signs. In addition, epidemiological and milk-production data from the affected farm is collected and analysed, and cattle movements on and off the farm are traced.

A key part of the clinical examination of affected animals is describing skin or mucosal lesions and assessing clinical features associated with fever and pain.

Clinical features associated with fever are:

- anorexia and/or lethargy; and
- elevated rectal temperature.

Clinical features associated with pain are:

- lameness, particularly with reference to the number of feet affected and the degree of pain;
- drooling;
- other signs of oral discomfort such as gritting teeth or lip smacking; and
- teat lesions, with reference to pain experienced at milking.

Useful terms to describe skin and mucosal lesions include macule, papule, vesicle, pustule, scab, erosion and ulcer. However, incorrect use of terms can result in confusion as to the potential aetiology. A pathological description of the lesions can sometimes convey a more accurate picture of what the lesions are likely to be (see Figures 1–11). Digital images of lesions are helpful but complement rather than replace a verbal or written description. The following terminology has been developed from the list used by the National Centre for Foreign Animal Disease in Winnipeg, Canada:

- distribution: where and how many;
- consistency: fluid-filled or hard;
- colour: hyperaemia present or absent; colour of vesicular fluid;
- shape: elevated, depressed, flat, nodular or round;
- size: dimensions of the lesions; and
- other features such as whether odour is present.

Epidemiological farm data collected from each animal include ear tag and lifetime identification of affected cattle, age and breed, and the date when clinical signs were first observed. With multiple cases, the management group (stratum) of each affected animal is determined. The point prevalence is then calculated for each group. Any differences in prevalence may provide evidence for specific factors being part of the aetiology of disease.

Further analysis of differences in prevalence of disease by stratum (age, management group, calving group) can be carried out using data from the Livestock Improvement Corporation (LIC), Hamilton. However, this is not generally useful during the early stages of FMD exclusion as it takes several days and analysis is not generally completed until after the initial visit.

Farm history is often sufficient to explain any drop in milk production, and further analysis can quantify such changes. If the farmer is a Fonterra supplier, milk-production data can be downloaded from the Fencepost website (Anonymous, 2010) and analysis completed before a field visit by veterinarians.

Milk production, measured in terms of volume (litres) and weight of milksolids (kg), is compared for two periods based on when the first case was observed. The first period consists of two days (incubation period) prior to first clinical signs being observed until the date of investigation. Production is compared to that immediately prior to this period. Data need to be corrected for any trend in production that is unrelated to disease, for example the seasonal variation in the herd's milk production. The calculated linear regression coefficient for production can be used to correct data for comparisons. It is possible to set up analyses in advance using software such as 'R' (Ihaka and Gentleman, 1996).

If FMD is suspected on clinical and epidemiological grounds, various response actions are instigated. These include collecting samples for laboratory confirmation and taking steps to prevent spread. These are not discussed further in this paper, which focuses on the key features of several investigations of suspect FMD.

Cases where FMD has been excluded

Four case studies are described where investigation was necessary to exclude FMD (Table 2). In all cases FMD was excluded, but the aetiological cause of lesions was not determined.

TABLE 1: USUAL CLINICAL AND EPIDEMIOLOGICAL FEATURES ASSOCIATED WITH INFECTION OF FMD AND FMD DIFFERENTIAL DISEASES

	MORBIDITY	COMMONLY AFFECTED AGE GROUP	CORONITIS AND/OR LAMENESS	TEAT/S AFFECTED	VESICLES PRESENT	FEVER PRESENT IN EARLY STAGES	USUAL LOCATION OF LESIONS	LESION DESCRIPTION
Food and mouth disease	High	All	Yes	Yes	Yes	Yes	Mouth, muzzle, feet	Vesicle, erosions
Papular stomatitis	High	<20 months	No	Yes	No	Yes	Mouth, muzzle, nasolabium, oesophagus, teats	Papule/erosion
Malignant catarrhal fever	Sporadic	1–2-year-olds	Possibly	No	No	Yes	Mouth, muzzle, eyes, intestine, kidneys	Erosions/ulcers, crusting around the muzzle
Bovine viral diarrhoea	1 or more	1–2-year-olds	Possibly	No	No	No	Oral cavity, nasolabium, gastrointestinal tract, feet, skin	Erosions/ulcers, crusting around the muzzle
Phototoxic dermatitis	Sporadic	All	Possibly	Yes	Possibly	Yes	Non-pigmented skin (and ventral, tip and sides of tongue)	Subcutaneous swelling/skin necrosis
Wood tongue	Sporadic	All	No	No	No	No	Oral cavity	Firm, often elevated lesions
Oral trauma	1 or more	All	No	No	No	No	Oral cavity	Lacerations

TABLE 2: SUMMARY OF KEY ASPECTS OF FOUR INVESTIGATIONS WHERE FOOT AND MOUTH DISEASE (FMD) AND ENDEMIC DIFFERENTIALS FOR FMD WERE EXCLUDED*

CASE	DATE OF INVESTIGATION	AGE OF CATTLE	FEVER PRESENT	VESICLES PRESENT	MAIN LESION	LAMENESS OR TEAT LESIONS	DROP IN MILK PRODUCTION	HERD PREVALENCE
1	15/3/2010	Mixed	No	Yes	Erosions of oral mucosa	No	No	0.3% (1/330)
2	20/9/2006	Mixed	No	No	Erosions of oral mucosa	No	No	40–60% (n=220)
3	5/12/2006	9 months	Yes	No	Erosions of oral mucosa	No	-	30% (9/30)
4	22/11/2005	Mixed	No	Yes	Erosions of oral mucosa	No	No	80% (n=397)

* Bovine viral diarrhoea (BVD) was excluded by Ag and Ab ELISA; malignant catarrhal fever (MCF) by PCR; papular stomatitis (PS) by histology and/or electron microscopy; phototoxic dermatitis (PD) by clinical signs; and woody tongue caused by *Actinobacillus liegenerisi* (WT) by clinical signs and histology.

CASE 1 (BAY OF PLENTY)

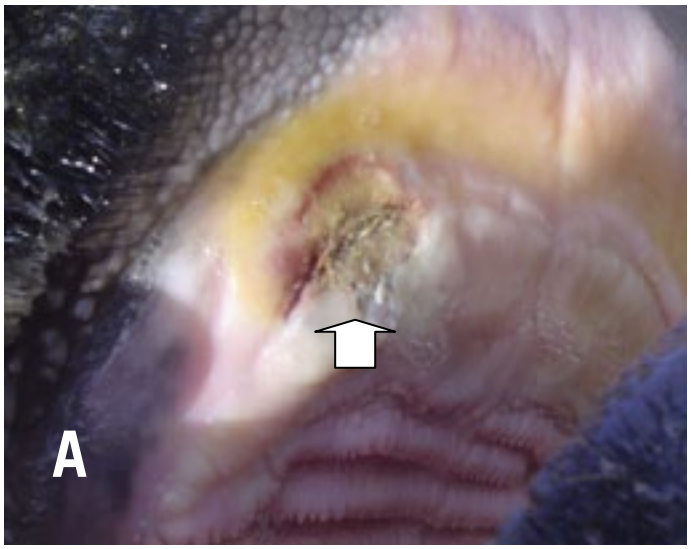
A six-year-old Friesian dairy cow presented with oral erosive lesions and several vesicles on the nasal plenum. The cow was mildly depressed, anorexic, displayed inspiratory dyspnoea and had a subnormal rectal temperature (37.5°C). Lameness and teat lesions were not apparent. None of the other 330 cattle in the herd were affected. There was a bilaterally symmetrical, firm swelling of the muzzle resulting in occlusion of the nostrils. An irregular-shaped erosive/ulcerative lesion was present on the right-hand side of the dental pad (Figure 1A). Several vesicles, generally circular in shape and 1–3cm in diameter, were present on the nasal planum (Figure 1B). Serosanguinous fluid was present in the vesicles. Cytological smears showed that the fluid consisted almost entirely of blood, with small numbers of degenerate neutrophils.

A standard screen for bovine health, including serum biochemistry (clotted blood), complete blood count and haematology (whole blood in EDTA), was carried out. A neutrophilia (7.6 x 10^9/L; reference range 0.6–4.5 x 10^9) and lymphopaenia (1.3 x 10^9/L; reference range 1.8–7.5 x 10^9) was present. There was an increase in liver enzymes: GGT was 325 IU/L (reference range 9–39) and GLDH was 112 IU/L (reference range 8–41). In addition, the cow was hypoalbuminaemic (24 g/L; reference range 27.8–45.3). The morphological diagnosis from histological sections of lesions was a necrotising dermatitis and stomatitis with epithelial separation and vascular thrombosis.

Although vesicles were present, lesions did not resemble those observed for vesicular disease. There was no sloughing of epithelium in the oral cavity or around the coronary band. The vesicles appeared to represent accumulation of fluid exudate resulting from necrosis of tissues in the epithelial and submucosal layers. Only one animal was affected and there was no effect on milk production.

The pathogenesis of lesions was not determined. We speculated that vesicular lesions could be secondary to inflammation/necrosis resulting from bacterial cellulitis, the initial point of entry of bacteria being from a penetrating wound in the dental pad. However, multifocal lesions observed histologically did not support this hypothesis. In addition, there was evidence that systemic disease was present.

The distinctive vesicles observed on the nasal planum of the affected cow were similar to those described in an outbreak of erosive stomatitis in a dairy cow herd (Case 4, below). However, in that case the prevalence of infection had been high and none of the affected animals had shown signs of systemic disease. It is possible that disease of different aetiology could produce the same type of lesions.



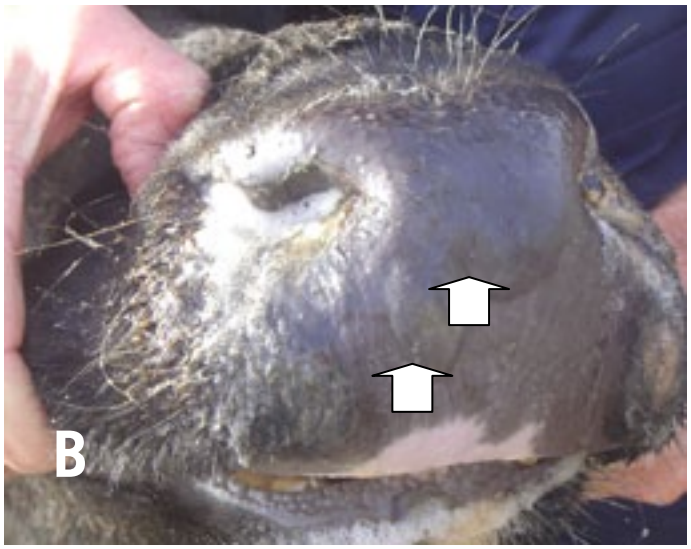


Figure 1 (Case 1): A discrete, ulcerated lesion on the lateral side of the dental pad, with yellow discoloration and odour indicating necrosis of underlying tissues (A; white arrow); and intact coalescing vesicles, incorporating about a third of the total area of the muzzle (B; black arrows).

CASE 2 (TARANAKI)

A herd of 220 dairy cows presented with a high prevalence (estimated to be 40–60 percent) of healing erosive oral lesions. The lesions were predominantly on the rostral part of the dental pad (Figure 2A). A circular, erosive lesion 2cm in diameter was present on the muzzle of one cow and on the dorsal surface of the tongue of another (Figure 2B). Lesions were not present on teats, the coronary bands or the interdigital region. Affected cows were not depressed, and rectal temperatures were normal (<40°C). There had been no drop in milk production in the days and weeks before this disease episode had occurred.

All tissues tested negative to parapox virus by electron microscopy and PCR. No viruses were isolated from specimens collected from lesions. Histological examination of tissues showed there was an acute to subacute vesicopustular stomatitis with acute to chronic vasculitis and collagen degeneration. In all tissue samples a distinctive feature was the subepithelial vasculopathy that affected the tissues from the epidermal junction to the depths of the sample. No environmental agent was identified that could explain a local caustic or toxic aetiology.

Figure 2 (Case 2): Erosive/ulcerated lesion covering the entire rostral surface of the dental pad from one affected dairy cow, with yellow and thickened sloughed epithelium (A; white arrow); and a circular erosive lesion, 2–3cm in diameter, (B; black arrow) on the rostral tip of the tongue of another affected cow.

CASE 3 (TARANAKI)

An investigation was carried out when nine five-month-old dairy calves from a mob of 30 (30 percent) presented with superficial erosions (Figure 3). The calves did not present with either fever or lameness.

Multiple irregular-shaped lesions were present on the dorsum and edges of the tongue, on the buccal mucosa and undersurface of the tongue. Lesions were up to 10cm long and 5cm wide, and some appeared to have coalesced.

Histologically the lesions were described as a subacute superficial pustular stomatitis. This lesion and the absence of demonstrable micro-organisms in the unruptured pustules suggested that the cause could be viral, toxic or allergic.

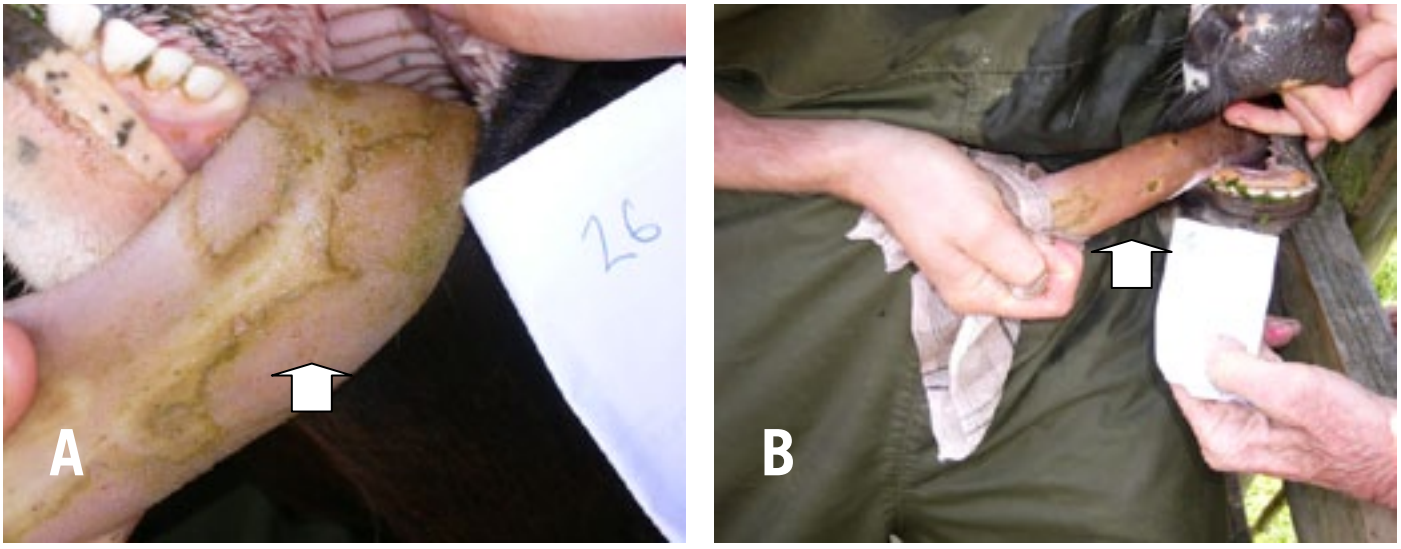


Figure 3 A & B (Case 3): Multiple irregular coalescing superficial erosive lesions (white arrows) covering about a third of the dorsal surface of the tongue of several nine-month-old calves.

CASE 4 (WAIKATO)

An investigation was carried out on a 397-cow herd that had healing oral erosive lesions (Figure 4B) in 80 percent of the herd. Intact vesicles were observed on the muzzles of two affected cows. None of the affected cows were systemically ill and there was no decrease in milk production.

Lesions were predominantly erosions. A single intact vesicle was identified on the muzzles of two cows during the investigation (Figure 4), as well as several ruptured vesicles on the muzzles of other cows. Erosions were generally circular in shape, and averaged 20mm in diameter (range 5–60mm). Twenty-one percent (7/34) of the cows had one oral lesion, 44 percent (15/34) had two, and 29 percent (10/34) had three or more lesions.

No infectious aetiological agent for any exotic infectious vesicular disease or any endemic cause of vesicular disease was detected using virus isolation, polymerase chain reaction (PCR), electron microscopy (EM) or serological tests. The investigation is described in detail by McFadden et al (2007).

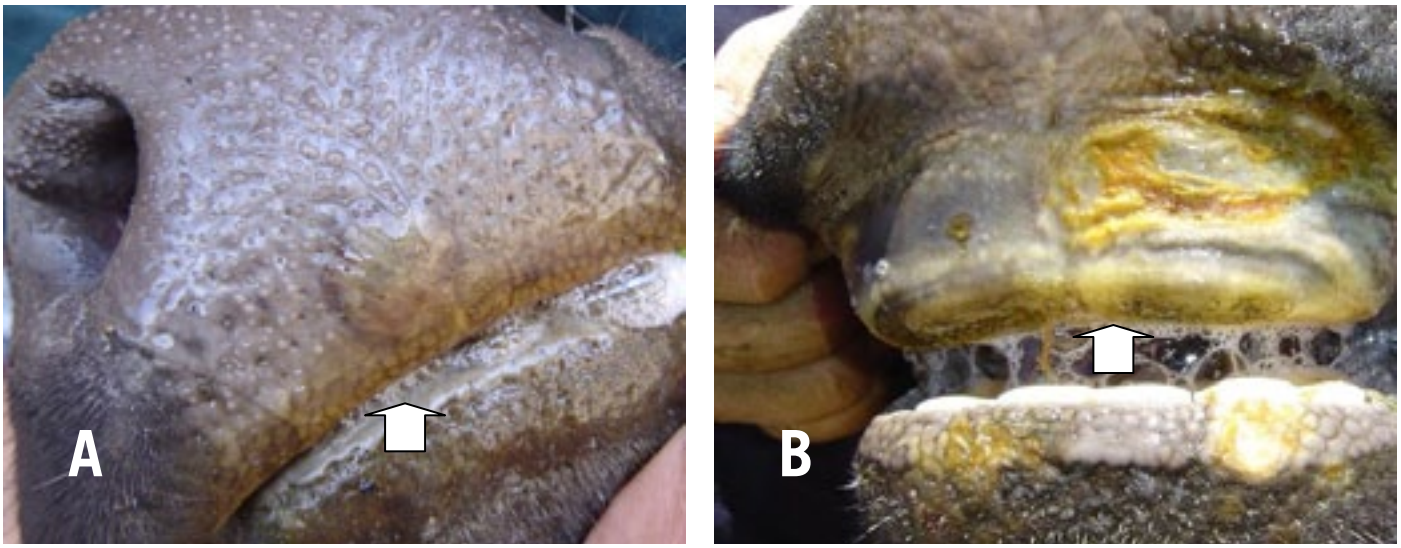


Figure 4 (Case 4): An intact, circular vesicle about 2cm in diameter (A; arrowed) on the lateral part of the muzzle, just dorsal to the lip of one affected dairy cow; and diffuse areas of erosion/ulceration (B; arrowed) on the rostral hard palate, upper and lower lip of another affected cow.

Recognition of FMD

Figures 5–11 show FMD and some of its common endemic differentials.

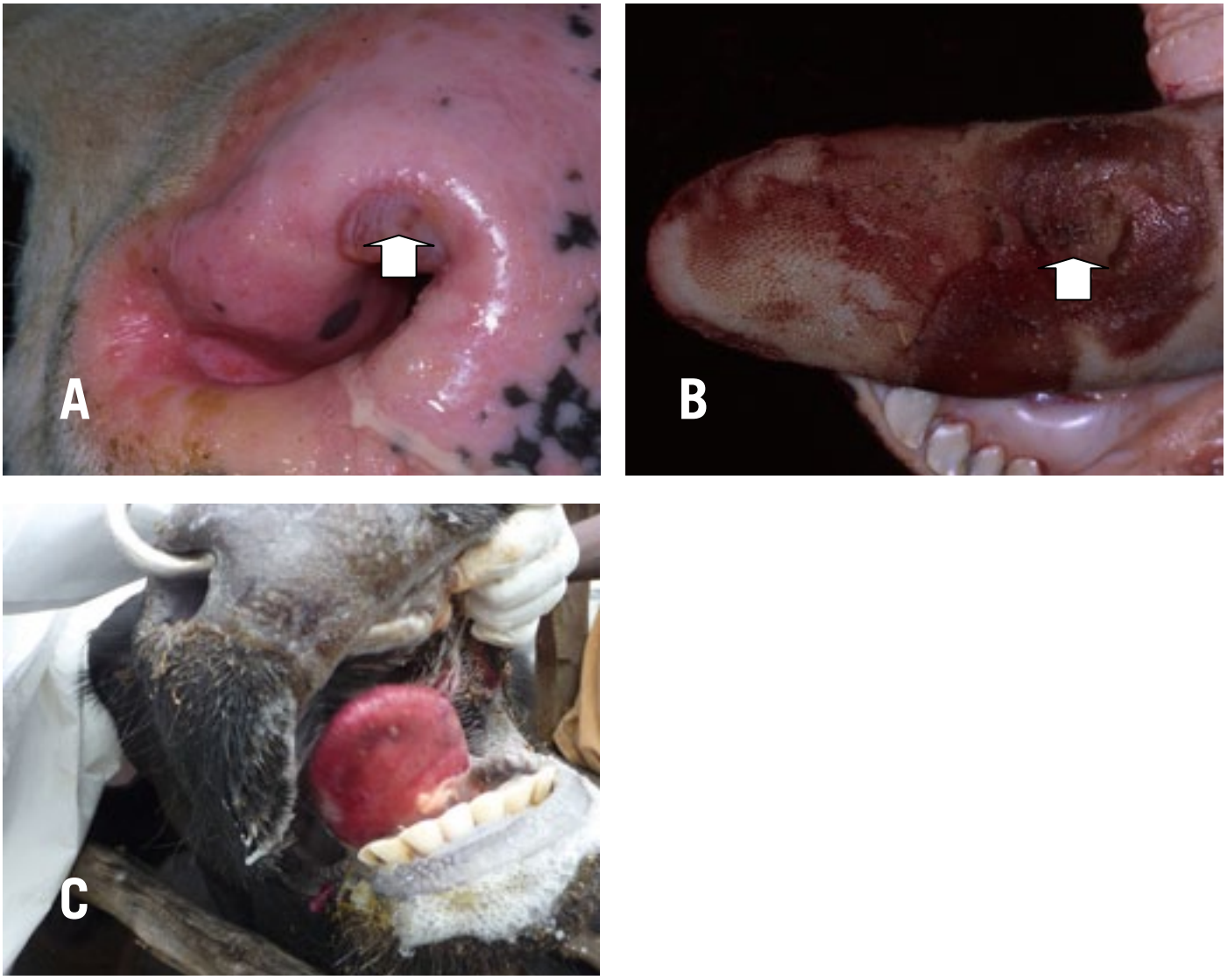


Figure 5: Foot and mouth disease lesions. A: A 2cm-diameter fluid-filled vesicle on the dorsal entrance to the nostril (arrowed). B: extensive areas of erosion covering about a third of the dorsal surface of the tongue (arrowed). (Photos courtesy of Dr Peter Fernandez, USDA, APHIS International Services, Regional Director for Europe, Middle East and Africa, Brussels, Belgium). C: Sloughing of epithelium from the rostral part of the tongue. (Photos courtesy of Mary van Andel, Investigation and Diagnostic Centre)

Figure 6: Endemic differentials for FMD: Papular stomatitis. A & B: multiple circular (about 5mm diameter) coalescing raised areas of hyperaemia, with white necrotic centres present on the nasal planum, lips and dental pad. (Photo courtesy of Donald Arthur, Selwyn Rakaia Vet Services Ltd). C: Hard palate. (Photo courtesy of Rob Fairley, Gribbles, Christchurch)

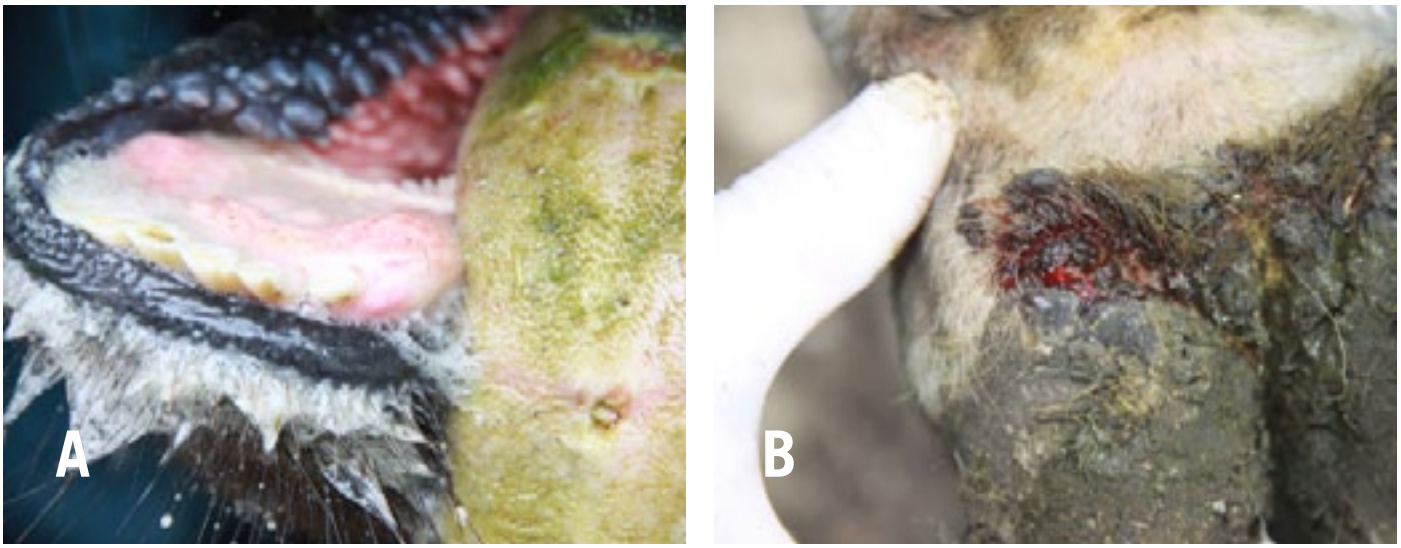


Figure 7: Endemic differentials for FMD: Bovine viral diarrhoea. A: multiple small (1–2mm diameter) erosive lesions on the dorsal surface of the tongue. B: Erosive lesions around the bulb of the heel and interdigital region. (Photos courtesy of Aaron McCullough, Aorangi Vet Services)

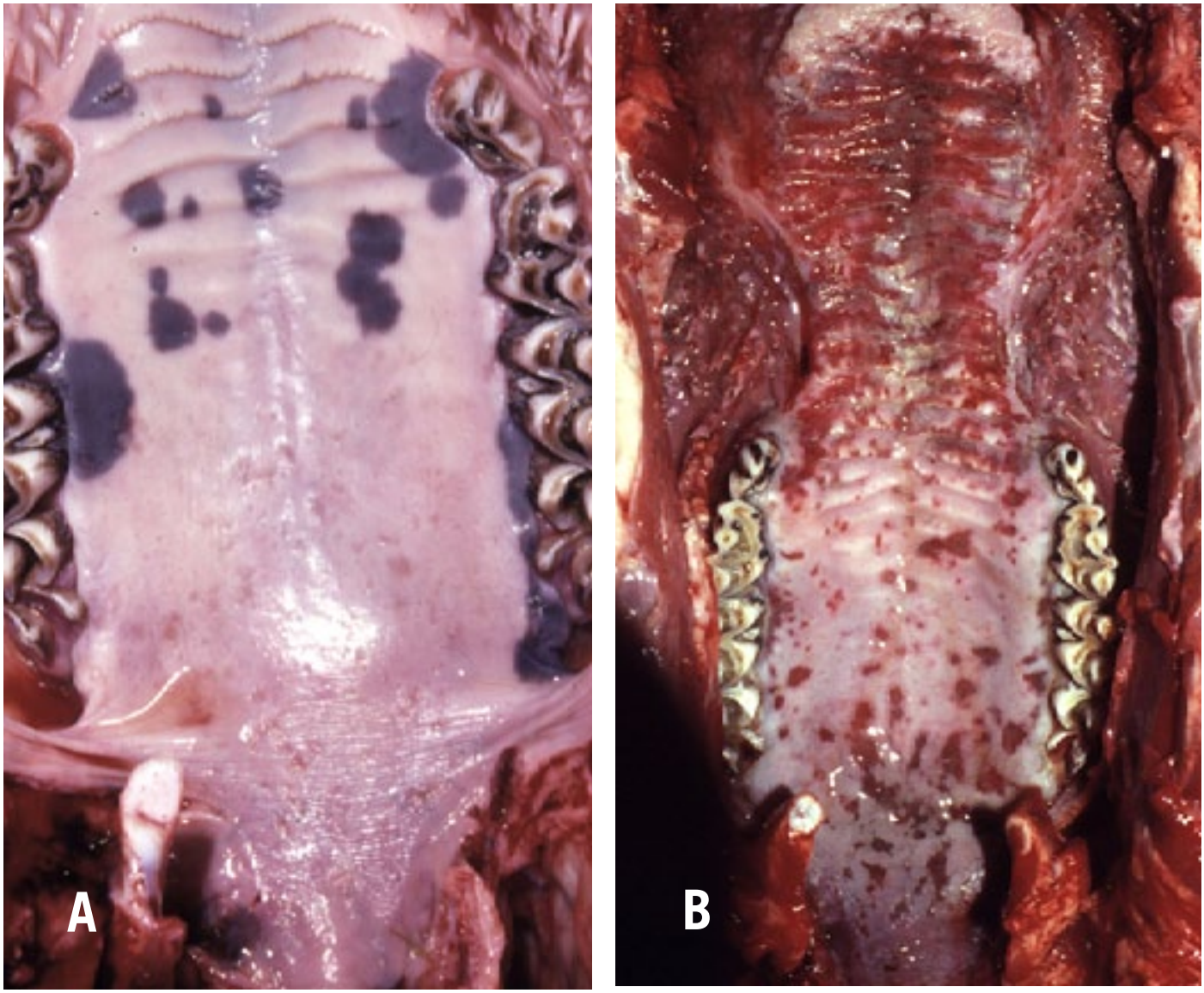


Figure 8: Endemic differentials for FMD. A: Bovine viral diarrhoea – multiple small (1–2mm diameter) healing erosive lesions on the hard palate.
B: Mucosal disease – areas of hyperaemia on the hard palate varying from small to large and extensive multiple coalescing irregular areas. (Photos courtesy of Keith Thompson, Massey University)

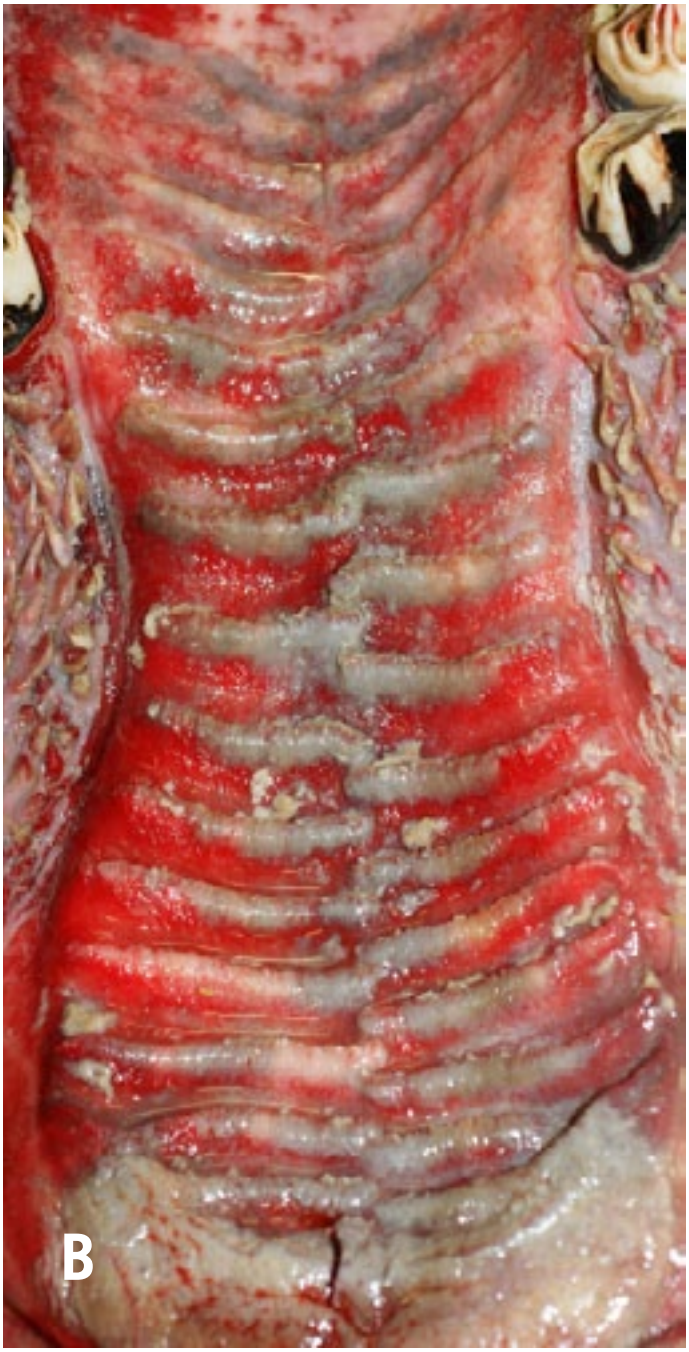


Figure 9: Endemic differentials for malignant catarrhal fever. Extensive areas of erosion and ulceration on the nasal planum (A) and hard palate (B), with underlying areas of haemorrhage, overlaid with necrotic epithelium. (Photos courtesy of Keith Thompson, Massey University). Corneal opacity and mucopurulent discharge from eyes and nostrils (C). Photos courtesy of Aaron McCullough, Aorangi Vet Services)

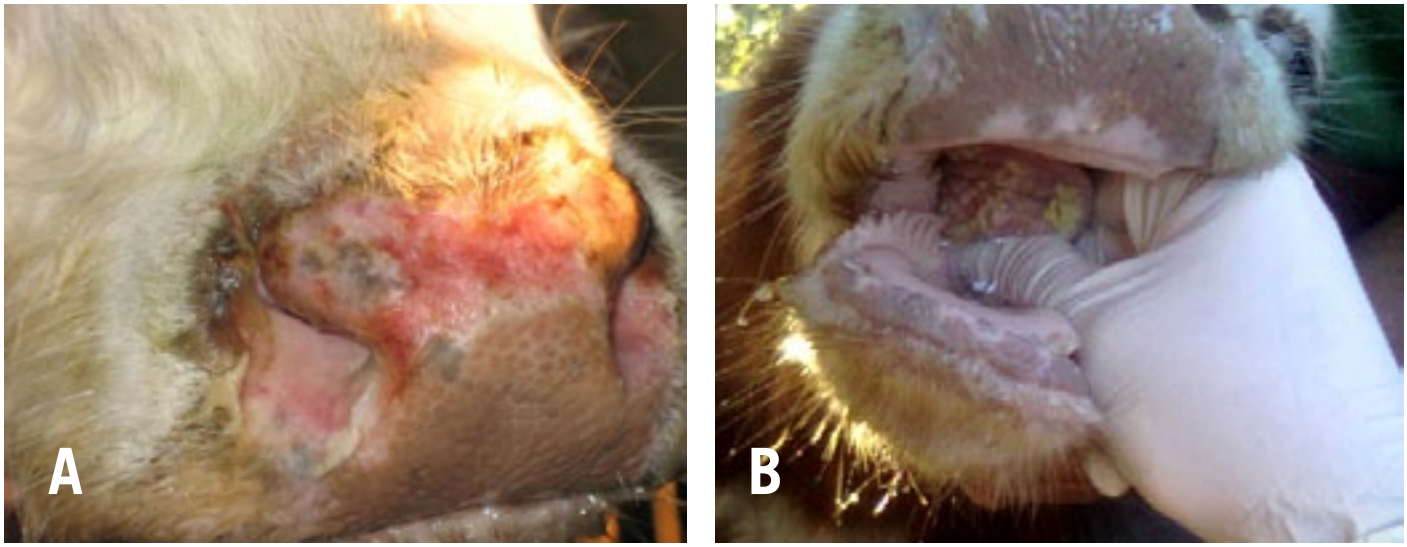


Figure 10: Endemic differentials for photosensitivity. Extensive areas of erosion on the dorsal nasal region (A) and the ventral surface of the tongue (B).

Figure 11: Endemic differentials for actinobacillosis ("woody tongue"). Granulomatous in appearance with extensive areas of irregular coalescing raised areas of hyperaemia, with patchy erosions on the nasal planum (A) and erosive lesions on the hard palate (B). Photos provided by Lester Laughton, AsureQualityNZ

Conclusion

This paper has summarised the epidemiological approach used by investigators at the IDC to exclude FMD from cases where suspicious signs are reported. The key findings from several investigations have been described where aetiology was not determined. None of the cases presented with signs expected from endemic FMD differentials (PS, PD, BVD, MD, MCF, woody tongue, traumatic injury). Thus lesion recognition forms only part of the investigation process and it is necessary to carry out a full investigation that incorporates results from clinical, laboratory and herd epidemiology to exclude FMD from these cases.

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